



# Aerosol, Clouds and Ecosystems (ACE)

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# ACE Charts Outline



- ◆ ACE Quad chart
- ◆ ACE Mission Study Overview
- ◆ ACE Study Mission Study budget
- ◆ ACE Mission study team FY08 Results
  - ◆ ACE Web Page sample
  - ◆ Developing STMs
  - ◆ Science Definition Team
  - ◆ STMs (4 slides)
- ◆ ACE study team FY09 Objectives
- ◆ Current Activities
- ◆ ACE – FY08-09 Schedule
- ◆ ACE - Issues and Challenges
- ◆ ACE Early Measurement Opportunity
- ◆ Field program plans



# ACE Mission Overview Quad



## Mission Science

ACE is a aerosol-cloud and ocean ecosystem mission

“... to reduce the uncertainty in climate forcing in aerosol-cloud interactions and ocean ecosystem CO<sub>2</sub> uptake” - Decadal Survey pg 4-4

Aerosol-cloud component science objectives are:

1. decrease the uncertainty in aerosol forcing as a component in climate change
2. quantify the role of aerosols in cloud formation, alteration of cloud properties and changes in precipitation.

Ocean ecosystem goals are to:

1. characterize and quantify changes in the ocean biosphere
2. quantify the amount of dissolved organic matter, carbon, and other biogeochemical species to define the role of the oceans in the carbon cycle (e.g., uptake and storage).

The ocean ecosystem imager needs aerosol measurements to optimize their retrievals which is an important reason for the combined payloads.

## FY09 Deliverables

Initiate early FY09 recommended studies including

1. OSSEs to address issues such as instrument capabilities, orbit, ...
2. ISALs for the potential instrument concepts
3. STM's for aerosols, clouds and ocean ecosystems

Late FY2009

1. IMDC / Team X runs to provide cost estimate
2. Final Report

Other activities:

- Four Science Definition Team Meetings – one open (June)
- Discussions with international partners on participation
- Field campaign planning including measurement strategy

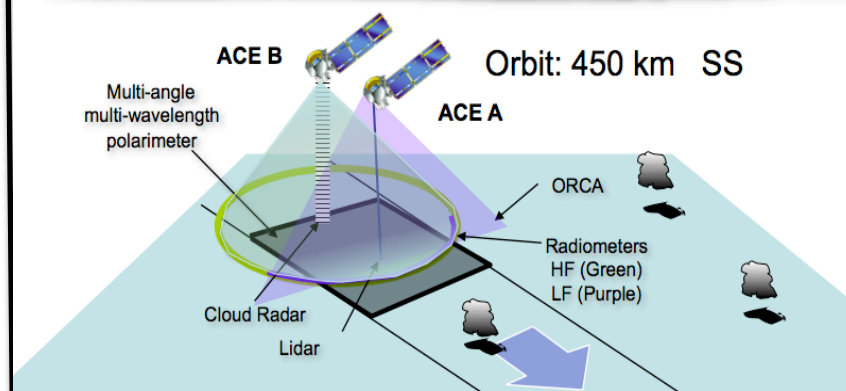
## Mission Implementation and Challenges

ACE Payload currently considers the following instrument candidates:

1. Lidar for assessing aerosol/cloud heights and aerosol properties. (TRL 4-6)
2. Dual frequency cloud radar for cloud properties and precipitation (TRL 4-6)
3. Multi-angle, swath polarimeter for imaging aerosol and clouds (TRL 4-6)
4. Ocean color multi-channel spectrometer for ocean ecosystems (TRL 5)
5. IR imager for cloud temperatures and heights (TRL 6)
6. High frequency swath radiometer for cloud ice measurements (TRL 6)
7. Low frequency swath radiometer for precipitation measurements (TRL 8)
8. Microwave temperature/humidity sounder (ATMS, TRL 9)

It is anticipated that all instruments will be openly competed. The payload may require more than one spacecraft.

Instruments in gray were mentioned in the NAS DS ACE description. The Science Working Group considers these overguide instruments critical to the mission.



Current thinking: ACE follows ESA EarthCare 3 yr mission at 10:30 AM, 450 km (2013 LRD). EC payload has Doppler radar and single channel HSRL lidar but no swath imager in visible or  $\mu$ -wave. ACE would provide continuity to EC and possibly overlap EC measurements for validation. ACE will have significantly improved radar, lidar and multi-wavelength imagers compared to EC and A-Train.



# ACE Mission Study Overview



## ◆ Development Activity

- *Science traceability matrices are close to finished*
  - ◆ Aerosol matrix is still under discussion – disagreement on polarimeter requirements
  - ◆ Cloud, ocean color matrix needing minor tweaks in measurement requirements
  - ◆ Applications to air quality on the aerosol side not defined
  - ◆ Applications to coastal management in good shape
- *Instruments*
  - ◆ Instrument teams plan to develop or are developing aircraft prototypes.
  - ◆ Plan is to fly these prototype instruments together to assess measurement strategy (e.g. joint retrievals, retrieval comparison, validation, ..)
- *Potential Partners – still in the exploration stage*
  - ◆ JAXA fly GCOM-W2 behind ACE (LF radiometer)
  - ◆ Japanese radar (?) – built EC Doppler W-Band radar
  - ◆ Canada provide components of radar (3 of 6 CSA concepts are ACE related)
  - ◆ CNES participation in polarimeter development

## ◆ Study implementation approach

- *Science Working Group selected by HQ and volunteers from community*
  - ◆ Three workshops scheduled this FY (one has already occurred)
- *Mission concept presented at Spring and Fall 2008 AGU meetings*
- *Community is behind expanded mission*
- *Mission Design Working Group to look at payload/orbit/cost trades*
  - ◆ Preliminary model for trade studies completed and presented at SLC
  - ◆ Consensus is developing on possibility lowering orbit to 450 km and flying with EarthCare



# ACE Study Team FY08 Results



## ♦ FY08 accomplishments

- *Kickoff ST workshop in June 2008*
- *Meeting with the Japanese in Hawaii July 2008*
- *Task working groups established, task leads identified, ST matrices refined*

## ♦ What happened at first workshop?

- *Original ACE DS was discussed*
  - ◆ HSRL measurements were identified as highly desirable
  - ◆  $\mu$ -wave radiometers added to the payload - will significantly increase science
  - ◆ IR imager identified as very highly desirable
  - ◆ Lower orbit (ACE was at 650 km in early HQ study) considered for ocean ecosystem radiometer and preferred by radar and lidar
  - ◆ Polarimeter cannot accommodate ocean spectrometer requirements
  - ◆ Multi-beam Lidar considered useful, the necessary weight, size and power requirements are of significant concern

## ♦ How were results recorded/documentated?

- *Presentations captured and posted on ACE web page*
- *2006 study report will also be posted on ACE web page*





# ACE Web Page is Under Construction



♦ Test page at <http://pprzyborski.gsfc.nasa.gov/ace/>

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## ACE

AEROSOL/CLOUD/ECOSYSTEMS MISSION

**ACE Home**

- About Aerosol/Cloud/Ecosystems Mission (ACE)
- Benefits of ACE
- Science of Aerosols and Precipitation
- Science of Ocean Ecosystems
- ACE Payload
- Schedule
- ACE Team

**Mission Status**  
The ACE Mission...

### AEROSOL/CLOUD/ECOSYSTEMS MISSION (ACE)

**What is ACE?**  
ACE is a tier 2 Decadal Survey mission focusing on clouds and aerosols as well as ocean ecosystems

**What will ACE do?**  
ACE will help to answer emerging fundamental science questions associated with aerosols, clouds, air quality and global ocean ecosystems. ACE is what these communities need to continue pioneering Earth System Science.

**Why two goals?**

- Ocean biology measurements and aerosols measurements meet at the algorithm level. Accurate estimation of the aerosol contribution to the backscatter radiation are required to make precise ocean biosphere measurements. Aerosol interference with ocean color measurements has been a major limitation in past missions
- There are common science problems between the two communities as well! Fertilization of the ocean by dust will change in the future with climate change. Aerosols are formed by oceanic emitted DMS and changes in the ocean ecosystem will alter the planetary energy budget.

**Ship tracks**  
**Smoke over clouds**  
**Drizzle**

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## 2nd Workshop Results: Developing the STMs



- ◆ Groups:
  - *Aerosols (climate and aerosol-cloud interaction) (Air Quality to be added)*
  - *Ocean ecosystems*
  - *Clouds (types of clouds, cloud precipitation, cloud-aerosol interaction)*
- ◆ Each group is taking a somewhat different approach
  - *Aerosols*
    - ◆ Aerosols range in size from nanometers to  $>10\ \mu\text{m}$ .
    - ◆ Key measurements are single scattering albedo, absorption, extinction, color, size distribution, and composition
    - ◆ Imagers: Multi-angle and multi-wavelength with polarization
    - ◆ Lidar estimates of extinction from which absorption can be estimated with altitude
  - *Clouds*
    - ◆ Different cloud types ranging from deep convection, to tropical cirrus to marine stratocumulus
    - ◆ Cloud drop sizes range from micrometers to hundreds of micrometers
    - ◆ Need multi-frequency radar and radiometers to extend swath sideways from narrow, nadir radar beam
  - *Ocean ecosystems*
    - ◆ Biological measurements beyond chlorophyll (e.g. plant physiology) and biogeochemical measurements (e.g. dissolved organic matter)
    - ◆ Need high sensitivity multi-wavelength visible near-UV-SWIR spectrometer
    - ◆ Need lidar to determine aerosol OD, type and height to estimate aerosol component of top of atmosphere radiance. Lidar also useful for particles in the ocean.
- ◆ Next step is to finalize and convert STMs to a common format



# Science Definition Team



ACE Science Working Group	Name
Management	
HQ	Maring, Hal, Bontempi, Paula
Science Leads	McClain, Chuck, Schoeberl, Mark
Coordinator	Vane, Deb
Ocean Biogeochemistry	
Theory/Modeler	Behrenfeld, Mike, Boss, Emmanuel
Retrievals	Ahmad, Zia, Wang, Menghua, Gordon, Howard, Arnone, Bob
OC Spectrometer	Smith, Jay, Waluschka, Gene, Wilson, Mark, Kotecki, Carl Meister, Gerhard, Holmes, Alan, Brown, Steve
Clouds	
Theory/Modeler	Jensen, Eric, Stephens, Graeme, Feingold, Graham, Wu, Dong, Marchand, Roger, Hou, Arthur
Retrievals	Ackerman, Steve, Platnick, Steve, Mace, Jay, Haddad, Ziad
Radar	Im, Eastwood, Heymsfield, Gerry, Racette, Paul, Durden, Steve, Tanelli, Simone
Aerosols	
Theory/Modeler	Colarco, Pete, Redemann, Jens, Nenes, Thanos, Toon, Brian, Westphal, Doug
Retrievals	Remer, Lorraine, Mishchenko, Michael, Kahn, Ralph, Hu, Yong
Polarimeter/Imager	Diner, David, Martins, Vanderlei, Cairns, Brian
Lidar	Welton, Judd, Hostetler, Chris, McGill, Matt, Wright, C. Wayne
Cal/Val	Starr, David, Hooker, Stan, Redemann, Jens
Radiation	Loeb, Norm, Kato, Seiji, Pilewskie, Peter
Mission Design	Devito, Dan, Boland, Stacey, Livermore, Tom



# Aerosol STM



Category	Focused Questions	Approach	Derived Parameter Requirements	Instrument Requirements	Platform Requirements	Other Needs
<b>Aerosols Clouds and Climate</b>	<ul style="list-style-type: none"> <li>How do different types of aerosols influence cloud development, microphysics and extent?</li> <li>How do anthropogenic aerosols affect within-atmosphere, top-of-atmosphere and surface radiation budgets?</li> <li>How do aerosol and cloud distributions vary over decadal time scales?</li> </ul>	<ul style="list-style-type: none"> <li>Establish an integrated program that combines climate modeling, coordinated suborbital measurements and ACE satellite observations.</li> <li>Strategy: <ul style="list-style-type: none"> <li>Conduct dedicated field observations of aerosol and cloud microphysics to improve cloud formation process models in global models.</li> <li>Use ACE satellite products to evaluate global model distributions of column averaged and vertically resolved aerosol amount, microphysics and absorption.</li> <li>Segregate ensembles with similar joint relationships between aerosol type, cloud type, and atmospheric state to establish aerosol-cloud effects not caused by meteorology or large-scale forcing.</li> <li>Compare aerosol-cloud relationships in the satellite data with those from climate models.</li> <li>Quantify decadal changes in cloud and aerosol properties by comparing ACE-derived global distributions of clouds and aerosols with those from prior missions (e.g., A-Train, EarthCARE).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Spectral (UV-VIS-SWIR) AOT, column. (<math>\pm 0.02</math> or <math>\pm 0.05 \cdot \text{AOT}</math>)</li> <li>Aerosol morphology</li> <li>Separation of aerosols and clouds with confidence.</li> <li>Global coverage over all surfaces: land, ocean, polar, deserts, cloud tops.</li> <li>Aerosol spectral (UV-VIS-SWIR) absorption (<math>\omega_0 \pm 0.03</math>).</li> <li>Aerosol spectral UV-VIS-SWIR) real part of the refractive index (<math>\pm 0.02</math>).</li> <li>Aerosol size distribution (resolved into bimodal, with modal effective radius to <math>\pm 10\%</math> and modal effective variance to <math>\pm 50\%</math>).</li> <li>Aerosol number concentration (<math>\pm 30\%</math>)</li> <li>Cloud optical thickness (<math>\pm 8\%</math>)</li> <li>Cloud droplet effective radius (<math>\pm 10\%</math>)</li> <li>Cloud droplet number concentration (<math>\pm 30\%</math>) and size distribution.</li> <li>Cloud horizontal and vertical extent.</li> <li>Column precipitable water vapor.</li> </ul>	<b>Multiangle, multispectral, polarimetric imager</b> <ul style="list-style-type: none"> <li>Spatial and temporal coverage sufficient to capture significant aerosol events in monthly mean statistics at global model grid resolutions.</li> <li>Horizontal resolution sufficient to retrieve aerosol in heterogeneous conditions.</li> <li>Sufficient absolute radiance calibration and polarization accuracy to meet derived parameter requirements</li> <li>Sufficient spectral resolution and range, angular resolution and range to meet derived parameter requirements</li> <li>May not meet all requirements across swath. Concentrate highest capability along lidar track.</li> </ul>	Orbit at 410 to 650 km for 2-day coverage. Active instruments prefer lower orbit  Sun synchronous 10:30 AM or 1:30 PM crossing time	Temperature and humidity profiles  Earth Radiation Budget measurements at TOA  Coordinated suborbital measurements (aerosol microphysical properties, AOD, spectral irradiance, cloud property evolution, updraft velocity, humidity profiles, CCN)
			<ul style="list-style-type: none"> <li>Vertically resolved aerosol morphology, extinction, absorption, real part of the refractive index, particle size and number concentration.</li> <li>Vertically resolved cloud optical thickness, effective radius, size distribution, thermodynamic phase and horizontal extent.</li> </ul>	<b>Lidar</b> <ul style="list-style-type: none"> <li>Vertical resolution sufficient to meet parameter requirements.</li> <li>Minimum dual wavelength and dual polarization</li> <li>HSRL or other technique to obtain direct determination of extinction</li> <li>Better SNR and depol than CALIPSO for daytime obs.</li> <li>Extended measure-</li> </ul>		



# Aerosol STM - 2



Category	Focused Questions	Approach	Derived Parameter Requirements	Instrument Requirements	Platform Requirements	Other Needs
<b>Aerosols Clouds and Precipitation</b>	<ul style="list-style-type: none"> <li>Do aerosols significantly influence the initiation, timing or total amounts of precipitation, and if so, how?</li> </ul>	<ul style="list-style-type: none"> <li>In addition to the approach and measurements necessary for answering the climate questions, the following additional measurements need to be made.</li> <li>Differentiate between precipitating and non-precipitating cloud condensates, and identify the type of condensate.</li> <li>Segregate by various categories such as aerosol type, cloud type or atmospheric state and composite ensembles by same types, then look for correlations between increases of aerosol or absorbing aerosol and changes in precipitation parameters.</li> <li>Isolate apparent aerosol-precipitation effects from meteorology and large-scale forcing.</li> <li>Compare relationships and trends found in the satellite record with same relationships in climate models. Apply critical constraints from the satellite record to the models.</li> </ul>	<ul style="list-style-type: none"> <li>Measurements to retrieve accurate total column aerosol and cloud properties, as above.</li> </ul>	<b>Polarimeter as above</b>	Orbit at 450 to 650 km for 2 day coverage. Active instruments prefer lower orbit  Sun synchronous 10:00AM to 2:00 PM crossing time	Temperature and humidity profiles
			<ul style="list-style-type: none"> <li>Measurements to retrieve vertically resolved aerosol properties, as above.</li> </ul>	<b>Lidar as above</b>		
			<ul style="list-style-type: none"> <li>Measurements of vertical profiles of cloud condensates with the ability to identify the type of condensate and span the size distribution from precipitating to non-precipitating.</li> <li>Measurements with sufficient resolution to resolve tall towers in the horizontal and stratus in the vertical.</li> </ul>	<b>Cloud Radar</b> - vertical resolution: 120 m (or better) - horizontal footprint: 1 to 2 km - Sensitivity of better than -30 dBZe (-40 dBZe desired) - Dual frequency (94&34GHZ) Scanning or Multibeam capability recommended but not critical ( <b>nadir only</b> )		
			<ul style="list-style-type: none"> <li>Global quantification of ice water content, bulk water and precipitation will provide critical constraint on global climate models.</li> </ul>	<b>High Frequency <math>\mu</math>-wave</b> High frequency microwave radiometer for IWC and cloud ice properties in combination with millimeter radar. Conically scanning ~53 deg incidence angle: 800-183 Ghz with 10 km footprint  <b>Low Frequency <math>\mu</math>-wave</b> Wide swath microwave radiometer for bulk water contents and precipitation also to be matched to radar. Conically scanning ~53 deg incidence angle: 10.66 – 183 Ghz with 10 km footprint.		



# Ocean Ecosystems STM



Focused Questions*	Approach	Maps to Science Question	Measurement Requirements	Instrument Requirements	Platform Needs	Other		
<div>1</div> What are the standing stocks, composition, & productivity of ocean ecosystems? How and why are they changing? [OBB1]	Quantify phytoplankton biomass, pigments, optical properties, key (functional/HABS) phytoplankton groups, and productivity using bio-optical models and chlorophyll fluorescence	1 2 6	Water-leaving radiances in near-ultraviolet, visible, & near-infrared for separation of absorbing & scattering constituents and calculation of chlorophyll fluorescence	<b>Ocean Radiometer</b> <ul style="list-style-type: none"><li>• 5 nm resolution 350 to 755 nm<ul style="list-style-type: none"><li>▷ 1000 – 1500 SNR for 15 nm aggregate bands UV &amp; visible</li><li>▷ 10 nm fluorescence bands (667, 678, 710, 748 nm centers)</li></ul></li><li>• 10 to 40 nm bandwidth atmospheric correction bands at 748, 865, 1245, 1640 nm (SNR T.B.D.)</li><li>• 0.5% radiometric accuracy</li><li>• 0.1% radiometric temporal stability</li><li>• 58.3° cross track scanning</li><li>• Sensor tilt (±20°) for glint avoidance</li><li>• Polarization insensitive (&lt;0.5%)</li><li>• 1 km spatial resolution @ nadir</li><li>• No saturation in UV to NIR bands</li><li>• 5 year minimum design lifetime</li></ul>	Orbit permitting 2-day global coverage of ocean radiometer measurements	Global data sets from missions, models, or field observations:  <i>Measurement Requirements</i> (1) Ozone (2) Total water vapor (3) Surface wind velocity (4) Surface barometric pressure (5) NO <sub>2</sub> concentration (6) Vicarious calibration & validation (7) Full prelaunch characterization		
	<div>2</div> How and why are ocean biogeochemical cycles changing? How do they influence the Earth system? [OBB2]	Measure particulate and dissolved carbon pools, their characteristics and optical properties					2 3	Total radiances in UV, NIR, and SWIR for atmospheric corrections
	<div>3</div> What are the material exchanges between land & ocean? How do they influence coastal ecosystems, biogeochemistry & habitats? How are they changing? [OBB1,2,3]	Quantify ocean photobiochemical & photobiological processes					2 4	
		Estimate particle abundance, size distribution, & characteristics	1 3 2					
	<div>4</div> How do aerosols & clouds influence ocean ecosystems & biogeochemical cycles? How do ocean biological & photochemical processes affect the atmosphere and Earth system? [OBB2]	Assimilate ACE observations in ocean biogeochemical model fields of key properties (cf., air-sea CO <sub>2</sub> fluxes, export, pH, etc.)	2	High vertical resolution aerosol heights, optical thickness, & composition for atmospheric corrections				
		Compare ACE observations with ground-based and model data of biological properties, land-ocean exchange in the coastal zone, physical properties (e.g., winds, SST, SSH, etc), and circulation (ML dynamics, horizontal divergence, etc)	3 4 5 6				Subsurface particle scattering & depth profile	
	<div>5</div> How do physical ocean processes affect ocean ecosystems & biogeochemistry? How do ocean biological processes influence ocean physics? [OBB1,2]	Combine ACE ocean & atmosphere observations with models to evaluate (1) air-sea exchange of particulates, dissolved materials, and gases and (2) impacts on aerosol & cloud properties	4					Broad spatial coverage aerosol heights and single scatter albedo for atmospheric correction. Subsurface polarized return for typing oceanic particles
	<div>6</div> What is the distribution of algal blooms and their relation to harmful algal and eutrophication events? How are these events changing? [OBB1,4]	Assess ocean radiant heating and feedbacks	5	<b>Polarimeter</b> <ul style="list-style-type: none"><li>• TBD</li></ul>				
		Conduct field sea-truth measurements and modeling to validate retrievals from the pelagic to near-shore environments	1 2 3 4 5 6					

\* ACE focused questions are traceable to the four overarching science questions of NASA's Ocean Biology and Biogeochemistry Program [OBB1 to OBB4] as defined in the document: *Earth's Living Ocean: A Strategic Vision for the NASA Ocean Biological and Biogeochemistry Program* (under NRC review)



# Cloud STM



**STMs developed for each of 5 cloud types.**  
**Deep Convection draft STM below**

Geophysical Parameters	Parameter	ACE Precision	Vertical Resolution	Horizontal Resolution
Convection	Occurrence Cloud	5%	<300 m R	0.5-1km,R <0.5km G
	Occurrence Precipitation		<300 m R	
	Cloud Top Height	<300 m,R	<300 m, R	
	Cloud Base Height	<300 m,R	<300 m,R	
	Cloud Phase	n/a	<300 m,R	
	Precip phase	20%	n/a	
	Precip type (stratiform /conv)		<300 m R (melting layer)	
Macro-physical	Ice and Liquid Water Content Profiles	20%?	<300 m,R	0.5-1km,R <0.5km G
	Ice and Liquid Water Paths	20%?	n/a	
	Ice and liquid particle size profiles	20% R	<300 m	
	Ice and Liquid Particle concentration profiles	30% R	<300m	
	Liquid precipitation amount	0.1-30mm/hr (surface)	<300m	
	Precipitation microphysics profile	20% ?R	<300m R	
Micro-physical	Latent heating profiles	TBD	<300m	0.5-1km,R <0.5km G
	Cloud Radiative Forcing (heating)	1 K/day/km	1 km	
	Cloud Radiative Effect	6 W/m <sup>2</sup> , R	n/a	
Radiative and latent energy				



# ACE FY09 Objectives/Plan



## ♦ Primary Activities

- ❑ *Complete work on Science Traceability Matrices*
- ❑ *Suborbital Instrument and ACE Simulator Tests*
  - ◆ Development of plans for field campaigns (see last slide)
  - ◆ Begin scheduling sub-orbital activities
- ❑ *Kickoff of Mission Design Working Group*
  - ◆ Development of payload options matrix
  - ◆ IDL work as needed
  - ◆ MDL and Team X studies of payload
  - ◆ Mission Cost estimate

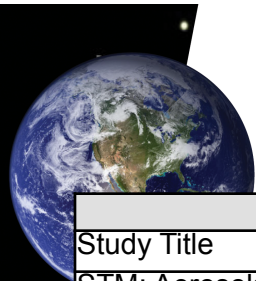
## ♦ Expected mission state at the end of FY09?

- ❑ *STM's complete*
- ❑ *Mission concept derived from STMs will be solidified*
- ❑ *Potential foreign partners identified*
- ❑ *Suborbital/field program developed*

## ♦ How will results recorded/documentated?

- ❑ *Mission report to HQ at end of FY09*
- ❑ *Web page documentation.*





# Current Activities



ACE Mission SWG Studies			
Study Title	Objectives	Lead(s)	Draft Completion Date
STM: Aerosols	Refine & Prioritize STM	Lorraine Remer	March 2009
STM: Ocean Ecosystems	Refine & Prioritize STM	Chuck McClain	March 2009
STM: Clouds	Refine & Prioritize STM	Graeme Stephens	March 2009
STM: Air Quality	Refine & Prioritize STM	Lawrence Freidl or designee, Pete Colarco	June 2009
Cooperative Retrieval Methodologies	Develop improved approach to retrievals of aerosols and ocean biogeochem	Zia Ahmad	March/April 2009
Joint Campaign Planning	Plan Joint Field Campaigns for science, risk reduction, and cal/val development	Jens Redemann, Stan Hooker/ Norm Nelson	March/April 2009
Modeling Studies / OSSEs / Instrument Studies/ Mission Studies			
Multi-beam Lidar Atmosphere	Assess value of multi-beam lidar aerosol characterization for CTM and climate model improvement	Pete Colarco	March/April 2009
Multi-beam Lidar Ocean	Assess value of multi-beam lidar aerosol characterization for ocean biogeochemistry retrieval improvement	Judd Welton	March/April 2009
Scanning Radar	Assess value of scanning radar on cloud property retrievals	Simone Tanelli, Gerry Heymsfield	March/April 2009
Frequency Choice for Radar	Assess value of various frequencies for radar cloud properties retrievals	Gerry Heymsfield, Simone Tanelli, Graeme Stephens	June 2009
High Spectral Resolution Lidar	Assess value of HSRL aerosol characterization for CTM and climate model improvement	Chris Hostetler, Matt McGill, Pete Colarco, Zia Ahmad	March 2009
Polarimeter Definition (Atmospheric)	Define polarimeter performance characteristics	Dave Diner, Michael Mishchenko	June 2009
Polarimeter / Ocean color in Single Instrument	Investigate the possibility of making polarimeter/imager measurements of aerosols, ocean color and clouds from a single instrument	Mike Behrenfeld	November 2008
Mission Design	Develop a matrix of mission scenarios to compare cost and science gain	Mark Schoeberl, Deborah Vane	September 2009





## Study FY08 - FY09 schedule

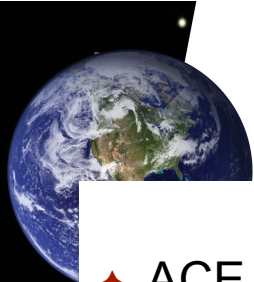


### ♦ FY09 Schedule

- ❑ *ST meeting Nov. 2008 (University of Utah)*
- ❑ *ST meeting Mar. 2009 (Oxnard, CA)*
  - ♦ *Task working group reports*
- ❑ *MDL, Team X studies begin May 2009*
- ❑ *Open ST meeting June 2009*
- ❑ *EC meeting – 10-12 June 2009 (Kyoto)*
- ❑ *Mission white paper, Sept 2009*

### ♦ FY10 Schedule

- ❑ *Additional science team meetings*
- ❑ *Field campaign work including aircraft flight opportunities*



## Study Issues & Challenges



- ◆ ACE is a multi-disciplinary climate mission; the Earth system science focus of ACE makes inclusion of the “additional” instruments (some called out in DS) and multiple platforms very important (e.g., meteorological parameters).
- ◆ ACE involves three communities. We are learning a lot from each other. The interaction is constructive.
- ◆ Need to develop coordination between appropriate Decadal Survey Missions for science (e.g., CLARREO, HYSPIRI, GEO-CAPE) and shared resources (e.g., data archives, ...).
- ◆ International coordination is a great possibility – we are engaging international partners informally. What is the coordinated official mechanism for doing so?
- ◆ Lidar and polarimeter technologies as well as ocean radiometer and radar could use some more funding to move them to aircraft flight TRLs faster
  - *ESTO IIP program should consider annual calls. Tight coordination with ESTO will transfer DS needs to IIP solicitation. Same for SBIR.*
  - *We are planning extensive airborne testing. Field campaigns can reduce uncertainties in joint retrievals – will require careful coordination for aircraft time.*
- ◆ Costing studies require knowledge of instrument costs but the payload and launch vehicle have not been selected – thus the costing numbers will be as precise as we would like.



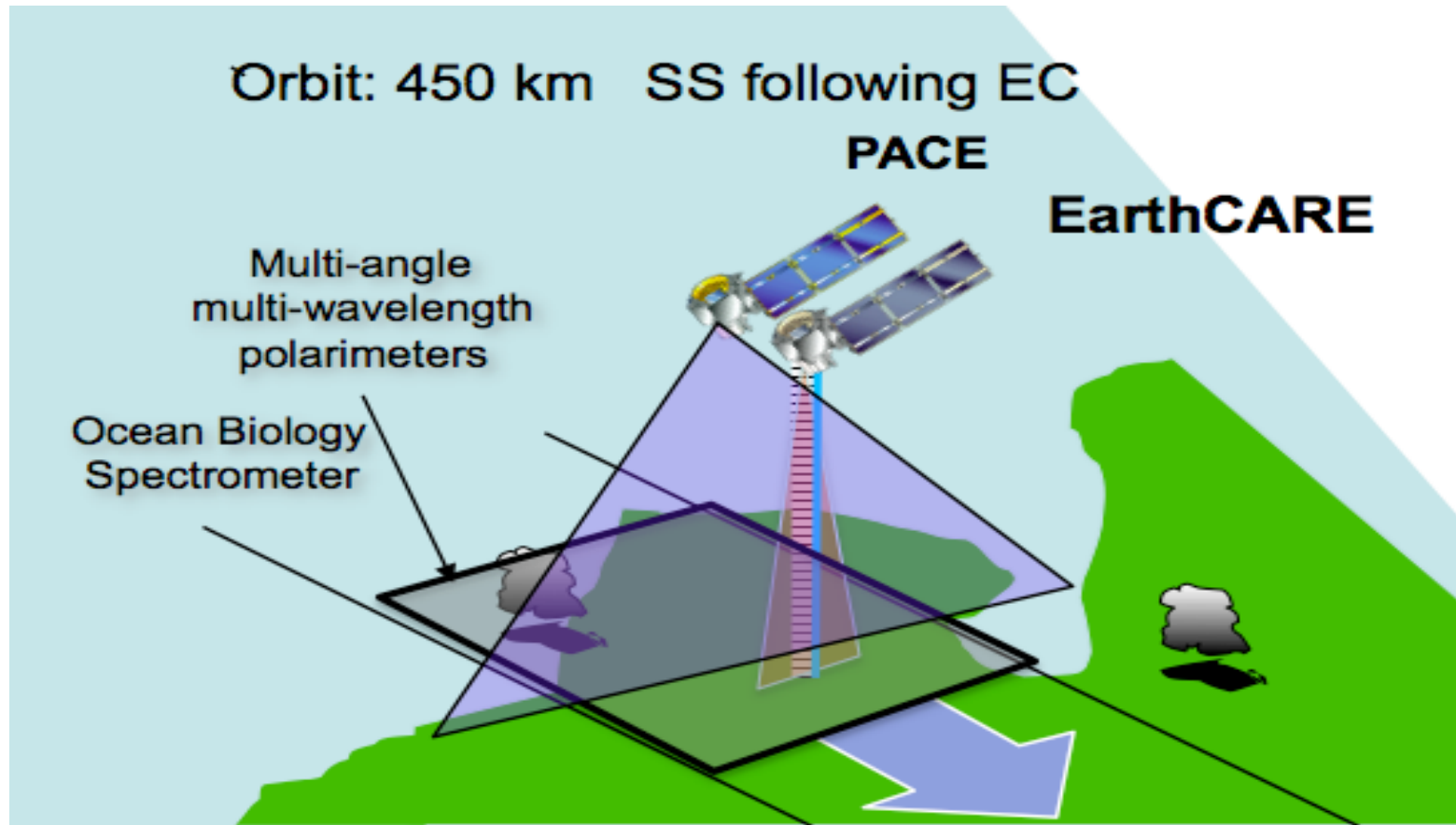
## Example of Mission Design Option: Early Measurements for ACE



- ♦ Earth Care launches in 2013. EC payload:
  - *Doppler W band radar*
  - *HSRL (single wavelength)*
  - *4 channel, 150 km - swath imager*
  - *Broadband stereo thermal IR imager*
- ♦ EC payload lacks a broad swath imager/polarimeter
- ♦ With the EC payload, the addition of a polarimeter and the ocean ecosystem spectrometer would give us a large fraction of the ACE measurement capability before 2018-20.
- ♦ Fly a polarimeter and ocean ecosystem radiometer behind EC, launch ~2015. Use Polder-A (CNES) and ORCA/GOCECP instrument design. Mission is small, use CNES bus, perhaps.
- ♦ Would give us early information on critical aerosol-cloud climate processes and continuity with ocean biosphere/chemosphere measurements
- ♦ Launch rest of ACE payload ~2018-20 behind EC. Form the E-Train.



# Pre ACE Concept





# ACE Field Program / Suborbital Science

WG Leaders: Jens Redemann, Norm Nelson, Stan Hooker, Mary Russ



## Summary: Suborbital Science Goals / Plans

- 1) The ACE suborbital science program is an integral part of the ACE science objectives as well as calibration and validation in all three of the ACE sub-disciplines.
- 2) Pre-launch activities will include:
  - *designated field programs to test suborbital simulators, refine sampling protocols, and investigate uncertainties*
  - *instrument development, such as the airborne simulators for the ACE instruments (including an instrument suitable for the testing of the simulators) and the field sensors needed to satisfy calibration and validation requirements*
  - *algorithm development and preliminary validation*
- 3) Post-launch activities will include:
  - *designated field campaigns for cal/val of orbital instruments and the estimation of uncertainties in the data products*
  - *sustained operation of suborbital platforms and sensors as defined by the overall mission science requirements*
- 4) We propose large, interdisciplinary experiments with coherent science objectives in cooperation with R&A and operating mission cal/val that can also serve cal/val requirements in the ACE post-launch timeframe.
- 5) We propose sustained measurement campaigns coordinated by Program Scientists/Managers and a calibration and validation office.
- 6) We are thinking of innovative strategies to use existing or emerging technologies, infrastructure, and data sets (e.g., dual-purpose field instruments for oceanic and atmospheric measurements, ground-based networks inside and outside of NASA-funded activities, and data sets from previous missions).

### Current Status:

- Bimonthly telecons; ca. 12 members in regular contact
- Presentation at November 2008 SWG Meeting, Salt Lake
- Working on white paper including field program science goals and the calibration and validation measurement requirements for all disciplines